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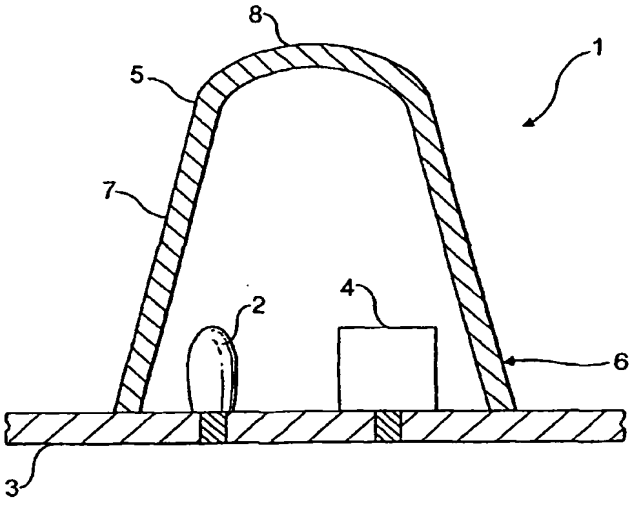
(54) Title: GAS SENSORS



(57) Abstract: A gas sensor (1) comprises an optical source (2) and detector means (4) sensitive to light from the source. The source and detector are electrically and physically connected to a circuit board (PCB) (3) which, together with a cover (5), forms part of a housing (6) for the source and detector. The sensor further comprises means arranged, in use, to admit gas into the housing, such as a porous cover or apertures in the PCB. The mounting of the source and detector onto a circuit board greatly simplifies the manufacture of such gas sensors. Advantageously, the sensor further includes a temperature sensor arranged to detect temperature inside the housing. Signals from the temperature sensor can be used to compensate for changes in the gas sensor output with changes in ambient temperature.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

GAS SENSORS

FIELD OF THE INVENTION

This invention relates to apparatus for, and methods of, sensing gasses. The invention particularly relates to such methods and devices in which optical radiation is transmitted through a gas and subsequently detected to provide information concerning the gas.

BACKGROUND OF THE INVENTION

In a typical gas monitor, an infrared source is arranged to emit radiation, which passes through a gas to be monitored. Infrared radiation is absorbed by the gas and that remaining is subsequently detected by an infrared detector. A comparison is made between the source intensity and the intensity of radiation detected following passage through the gas to give the concentration of a target gas.

The present invention seeks to provide a gas sensing device, which although manufactured economically from a minimal number of inexpensive components, performs its function as well as more sophisticated sensors.

SUMMARY OF THE INVENTION

The invention provides a gas sensor comprising an optical source and detector means sensitive to light from the source, the source and detector being electrically connected to a circuit board which forms part of a housing for the source and detector, and the sensor further comprising means arranged, in use, to admit gas into the housing.

The mounting of the source and detector onto a circuit board greatly simplifies the manufacture of such gas sensors. Previously, it has been thought desirable to mount the source and detector in special chambers, the inner contours of which are arranged to minimise stray light. Although such a gas sensor has good performance characteristics, the method of manufacturing the chamber and mounting the components therein is time-consuming and therefore more costly.

Preferably, the means for admitting gas into the housing comprises apertures in the housing, which apertures may be formed in the circuit board. Alternatively, or additionally, part of the housing may comprise sintered material to admit gas to the sensor.

Advantageously, the gas sensor further includes a temperature sensor arranged to detect temperature inside the housing. The output from the temperature sensor may be input to a control system arranged to

provide a signal to compensate for changes in the sensor output with ambient temperature.

The invention lends itself to the monitoring of carbon dioxide levels at and above critical and is therefore suitable for the detection of the presence of humans or animals in an enclosed environment. Therefore, the invention may be employed in a variety of security and rescue applications.

BRIEF DESCRIPTION OF THE FIGURES

The invention will now be described, by way of example, with reference to the accompanying drawings, in which: -

Figure 1 is a sectional view of a gas sensor constructed according to the invention;

Figure 2 is a sectional view of an alternative gas sensor constructed according to the invention;

Figure 3 is a sectional view of another alternative gas sensor constructed according to the invention;

Figure 4 is a sectional view of a further alternative gas sensor constructed according to the invention;

Figure 5 is a sectional view of a further alternative gas sensor constructed according to the invention;

Figure 6 is a sectional view of a further alternative gas sensor constructed according to the invention; and

Figures 7a and 7b are cross sectional views of channels suitable for inclusion in the sensor of Figure 6.

DESCRIPTION OF A PREFERRED EMBODIMENT

Like reference numerals relate to like parts throughout the specification.

With reference to Figure 1, a gas sensor constructed according to the invention is illustrated and indicated generally by the reference numeral 1. The gas sensor 1 comprises a source 2 of infrared (IR) radiation, electrically connected to, and physically mounted on, a printed circuit board (PCB) 3. The sensor 1 further comprises an infrared detector 4, which includes a bandpass filter. The detector 4 is also electrically connected to, and physically mounted on, the PCB 3. Suitable detectors include photodiodes, thermopiles and pyroelectric devices.

A cover 5 is provided for the source 2 and detector 4. The cover 5, together with the PCB 3 forms a housing 6 for the components of the

sensor 1. The interior surfaces of the housing 6 form an optical cavity. In order to obtain good reflectance of IR radiation in the optical cavity, the interior surfaces of the cover are coated with a metallic layer, for example gold. Any material that is highly reflective to IR radiation may be employed. The surface of the PCB onto which the components are mounted may also be coated with IR reflective material.

The cover 5 has a tapered wall 7 with a curved end portion 8 arranged so that, in the sectional view of Figure 1, the cover 5 resembles the shape of a thimble. In this embodiment, at least a portion of the cover 5 comprises a sinter, to allow gas to be admitted into the housing 6 by diffusion.

In use, the source 2 produces broadband IR radiation, which is reflected by the surfaces of the cavity and absorbed by the gas in the housing to a degree proportional to the amount of gas present. A range of wavelengths of the broadband IR radiation not absorbed by the gas is detected at the detector 4. The detector 4 generates an electrical signal corresponding to the strength of the detected IR radiation. This signal is input to processing electronics (not shown) arranged to determine the concentration of gas present in the housing. The concentration is related to the intensity by the following equation:

$$I = I_o e^{-\alpha c l}$$

where I is the intensity of radiation detected by the detector, 10 is the intensity of radiation emitted at the source, ϵ is effectively a constant which is dependent on the particular gas being monitored, c is the gas concentration and I is the distance travelled by the radiation through the gas.

The sensor and processing electronics may be configured to detect an increase or decrease (Δc) in concentration of the gas being sensed. Alternatively, absolute measurements of the concentration of a particular gas may be determined.

An alternative arrangement of the sensor of Figure 1 is shown in Figure 2. In this embodiment, the cover 9 comprises a solid shell of pressed metal. Gas is able to diffuse into the housing by means of apertures 10 in the PCB.

Another alternative sensor constructed according to the invention is shown in Figure 3. In this embodiment, the cover 11 is square or rectangular in section. This cover 11 includes porous material, for example a sinter, for the admittance of gas. Alternatively, the cover 11 could comprise a solid shell of pressed metal, in which case the PCB of would incorporate apertures for the gas. The advantage of this embodiment is that the cover is straightforward to manufacture.

In the sensor of Figure 4, the cover 12 comprises a straight cylindrical wall 13 having a dome 14 as a lid. The wall 13 and dome 14 may be of one-piece construction. This sensor includes an apertured PCB for the admittance of gas. The cover of the Figure 4 embodiment is less simple to manufacture than the basic cubic shape of the cover of the Figure 3 embodiment. However, the domed lid ensures that a greater proportion of light is directed onto the detector.

A further alternative gas sensor is illustrated in Figure 5. In this embodiment, the cover 15 comprises a pipe 16, one end portion 17 of which is arranged to surround the source 2 of IR radiation. The other end portion 18 of the pipe is arranged to surround the detector 4. The pipe 16 forms an inverted "U" over the PCB. The pipe 16 may comprise a sinter or else have a plurality of apertures (not shown) in its walls. An advantage of this embodiment is that the pipe provides a predefined optical path for radiation traveling from the source to the detector. Thus, stray light is minimised. The inverted "U" shape of the pipe provides a relatively long optical path as well as providing a large surface area for gas to diffuse into the cover.

In the alternative sensor of Figure 6, the source 2 and detector 4 are spaced apart. The cover 19 comprises a solid metallic shell arranged to provide an elongated channel between the source 2 and the detector4. In this embodiment, diffusion of gas into the housing is effected by means of apertures in the PCB.

The cover 19 of Figure 6 may be square or rectangular in cross section, as illustrated in Figure 7a. Alternatively, the cover may have a curved upper surface so that it is arch- shaped in cross section as shown in Figure 7b. Of course, the cover could take on any shape required, for example domed, pyramidal, etc, in order to enhance the proportion of radiation incident on the detector.

The gas admittance means could comprise apertures in the PCB, apertures in the cover, a sinter forming part of the cover or any combination of these.

Further variations may be made without departing from the scope of the invention. For example, a reflector may be located adjacent the source of IR radiation and arranged to reflect light in a desired direction or range of directions.

A replaceable particle filter, for example a microporous membrane of Gore-Tex ®, may be provided over the gas sensor in order to prevent dirt particles, water droplets and other contaminants from entering the sensor.

A temperature sensor (not shown) in the form of a thermistor, for example, may be incorporated in the sensor to provide a signal representing the temperature in the sensor to a control system, which employs suitable algorithms to provide temperature compensation of the output signal from the detector.

The invention is particularly suitable for detecting levels of carbon dioxide in an environment. Alternatively, an increase in concentration of carbon dioxide levels may be detected. The gas sensor constructed according to the invention typically has an optical path length in the range of forty to sixty millimetres approximately. It has been found that this is suitable for detecting levels of carbon dioxide in the range of 500 ppm to 10,000 ppm. The IR source and detector may be tuned to the absorption band of carbon dioxide at 4.2 microns. A gas sensor configured to detect carbon dioxide is suitable for a wide range of applications as such a sensor can detect the presence of humans or animals in an environment.

CLAIMS

1. A gas sensor comprising an optical source and detector means sensitive to light from the source, the source and detector being electrically connected to a circuit board which forms part of a housing for the source and detector, and the sensor further comprising means arranged, in use, to admit gas into the housing.

2. A gas sensor as claimed in claim 1, wherein the means for admitting gas into the housing comprises at least one aperture in the circuit board.

3. A gas sensor as claimed in claim I or 2, in which the means for admitting gas into the housing comprises at least one aperture in the housing.

4. A gas sensor as claimed in anyone of claims I to 3, in which the means for admitting gas into the housing comprises sintered filter material which forms at least part of the housing.

5. A gas sensor as claimed in any previous claim, in which at least part of the interior of the housing is coated with IR reflective material.

6. A gas sensor as claimed in any previous claim, further comprising a reflector associated with the source.

7. A gas sensor as claimed in any preceding claim, further comprising processing electronics arranged, in use, to determine the presence of a predetermined gas in dependence on signals from the detector.

8. A gas sensor as claimed in claim 7, in which the processing electronics is arranged to detect a change in concentration of the predetermined gas.

9. A gas sensor as claimed in claim 7, in which the processing electronics is arranged to determine absolute concentration of the predetermined gas

10. A gas sensor as claimed in any previous claim, further comprising a temperature sensor.

11. A gas sensor as claimed in claim 10, further comprising compensating electronics arranged to compensate for changes in temperature detected by the temperature sensor.

12. A gas sensor as claimed in any previous claim, further comprising a particle filter.

13. A carbon dioxide detector including a gas sensor as claimed in anyone of claims 1 to 9.

14. A gas detection system including a gas sensor as claimed in anyone of claims 1 to 9.

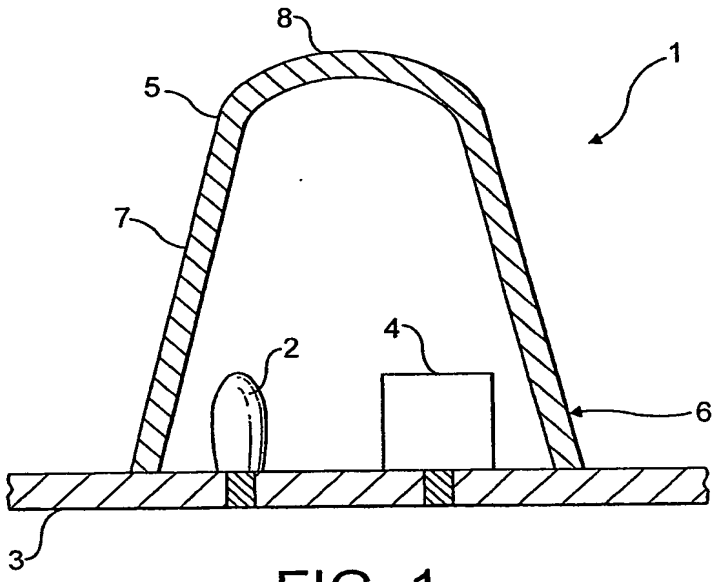

FIG. 1

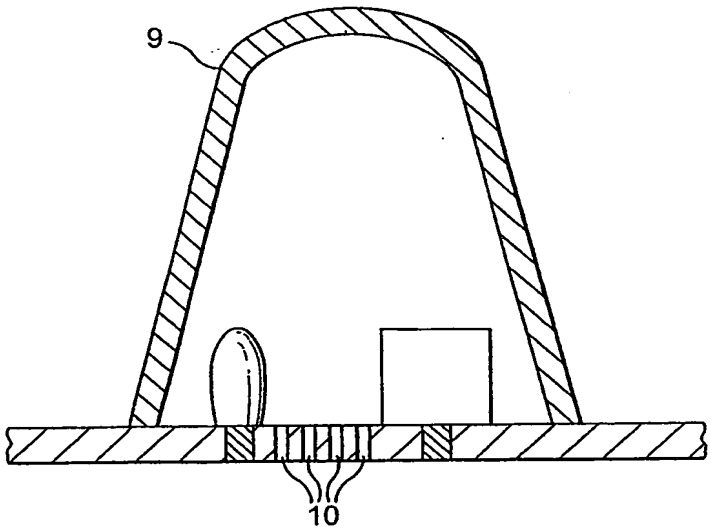

FIG. 2

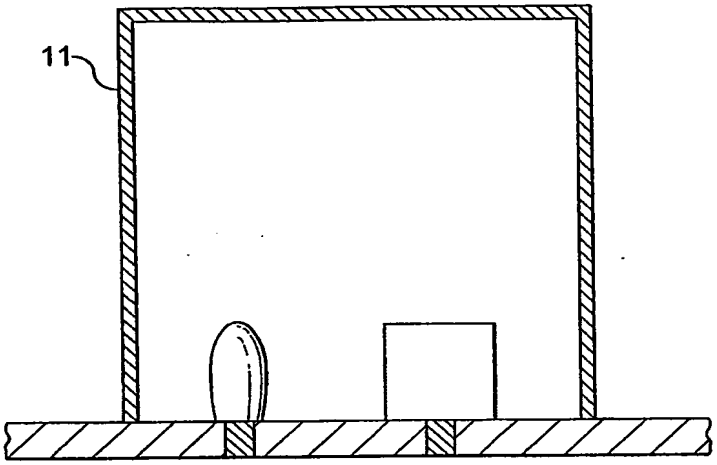

FIG. 3

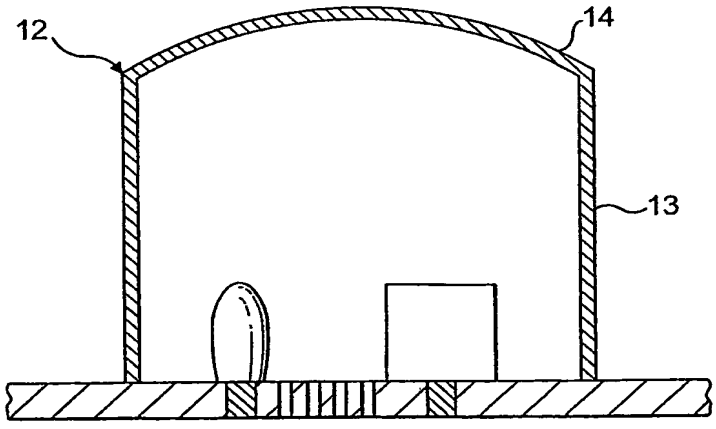

FIG. 4

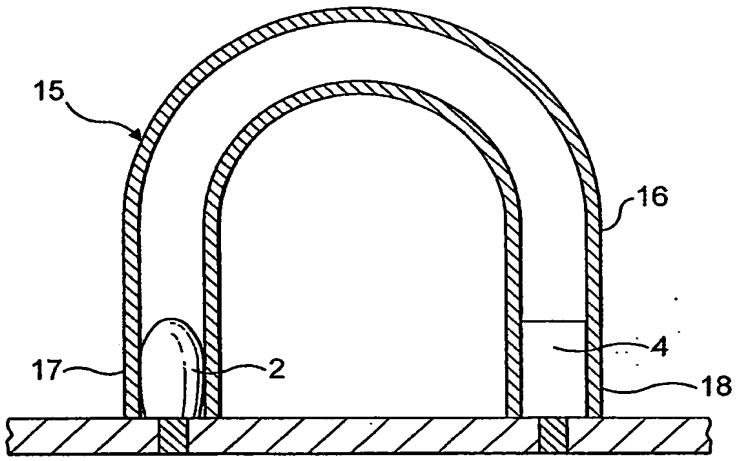

FIG. 5

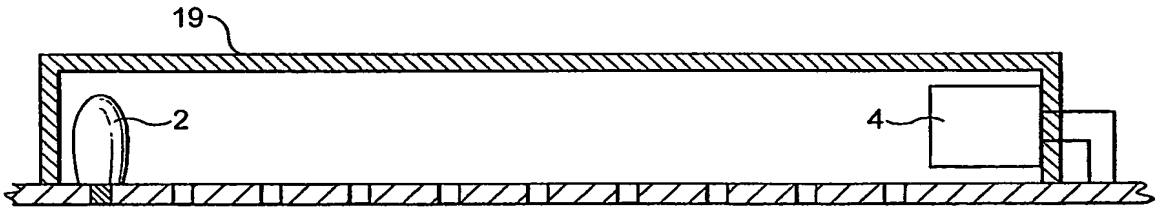

FIG. 6

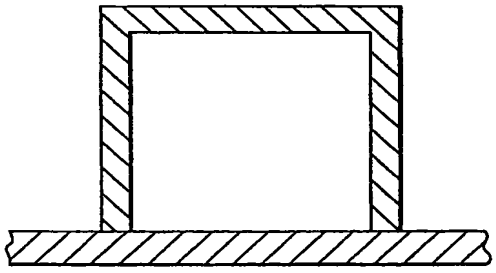

FIG. 7a

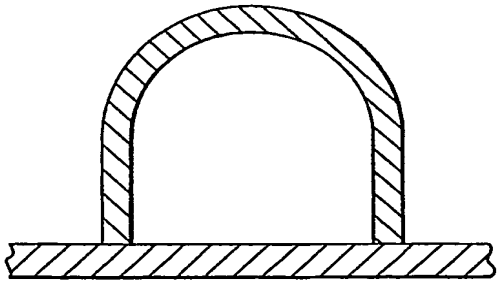

FIG. 7b

INTERNATIONAL SEARCH REPORT

PCT/GB 03/03782

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G01N21/35 G01N33/00 G01N21/03

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
COMPENDEX, EPO-Internal, INSPEC, PAJ, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	US 6 201 245 B1 (SCHRADER ROBERT J) 13 March 2001 (2001-03-13) column 8, line 6 - line 47 figures 1,2	10,11

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"A" document defining the general state of the art which is not considered to be of particular relevance

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Date of the actual completion of the international search	Date of mailing of the international search report
1 December 2003	10/12/2003

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Verdoodt, E

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INTERNATIONAL SEARCH REPORT

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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Form PCT/ISA/210 (continuation of second sheet) (July 1992)

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